Seminar 2
Introduction to modern portfolio theory: the set up

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Data Analysis in Economics and Finance

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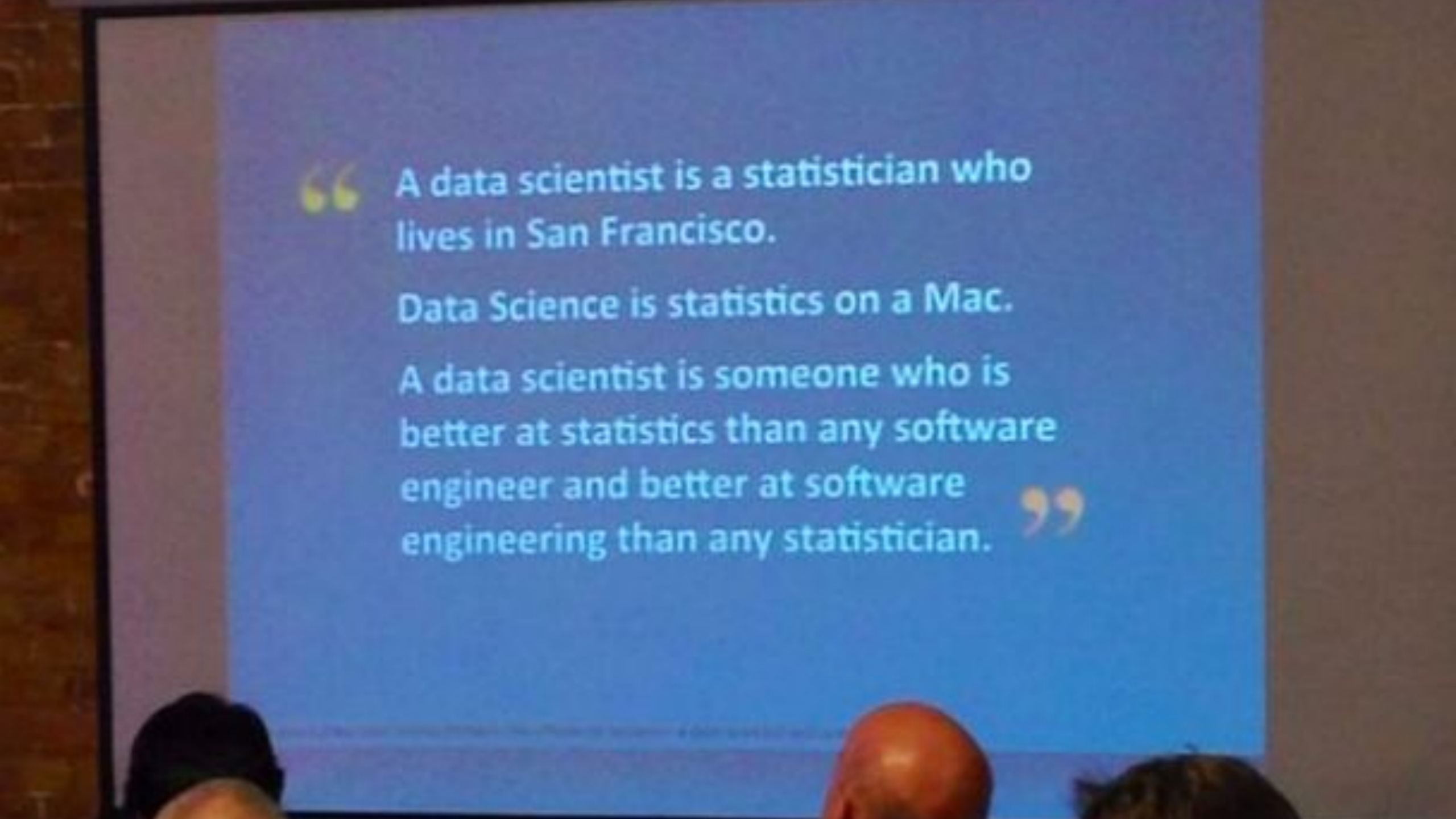
A data scientist is a statistician who lives in San Francisco.
Data Science is statistics on a Mac.
A data scientist is someone who is better at statistics than any software engineer and better at software engineering than any statistician.

Recent view on quantitative methods in decision-making

- Quantitative funds would never rule the space
- They are “black boxes” that recommend counter-intuitive trades, bets that nobody can understand

Most successful hedge funds (as of 2017)

- Renaissance Technologies ($42 billion assets under management, up 42% from the previous year)
- AQR Capital Management ($69.7 billion AUM, up 48%)
- Two Sigma ($51 billion AUM, up 28%)
- Bridgewater Associates ($122.3 billion AUM, up 17% from 2015)
- In general: five of the six largest firms in this 2017 ranking rely on computers and algorithms to make their investment decisions (Institutional Investor)

Role of data analysis in modern finance

- Investment shops are fighting over mathematicians and engineers
- FinTech
- “Half of the books about finance are written by authors who have not practiced what they teach. They contain extremely elegant mathematics that describe a world that does not exist. The other half of the books are written by authors who offer explanations absent of any academic theory. They misuse mathematical tools to describe actual observations”. (Lopez de Prado)
- Data analysis fills the gap between theory and practice

Big data in action

- Parking lots traffic
  - In 2015 certain hedge funds utilizing satellite data sources noted rising traffic in the parking lots of J.C. Penny stores
  - This was a clear sign of increasing sales
  - JCP's stock jumped more than 10% when public reports of JCP's increased store traffic came to light in August.
- Crop estimates
  - In 2015 some investment firms examined infrared satellite images taken of over one million corn fields
  - They correctly predicted that U.S. corn production was 2.8% smaller than prevailing government estimates
- Successful market guessing requires data analysis skills!

Course objective

- Look at one particular application of data analysis
- Make it as close to practice as possible
- Avoid the misuse of mathematics
- Ultimate goal: build an investment portfolio
  - Discuss modern approaches
  - Gather financial data
  - Compute optimal asset allocations
  - Evaluate historical performance
  - Track out-of-sample results

General workflow in the asset management industry

- Understand client (or your own) needs
- Formalize requirements
- Build an algorithm that produces tailored portfolio

Your projects

- How did you pick assets?
- How did you match characteristics of your portfolio to client profiles?
- How did you assign weights?
- What measures did you use for selecting the best portfolio?

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How well have your portfolios performed since inception?

Let’s go to investing.com and check

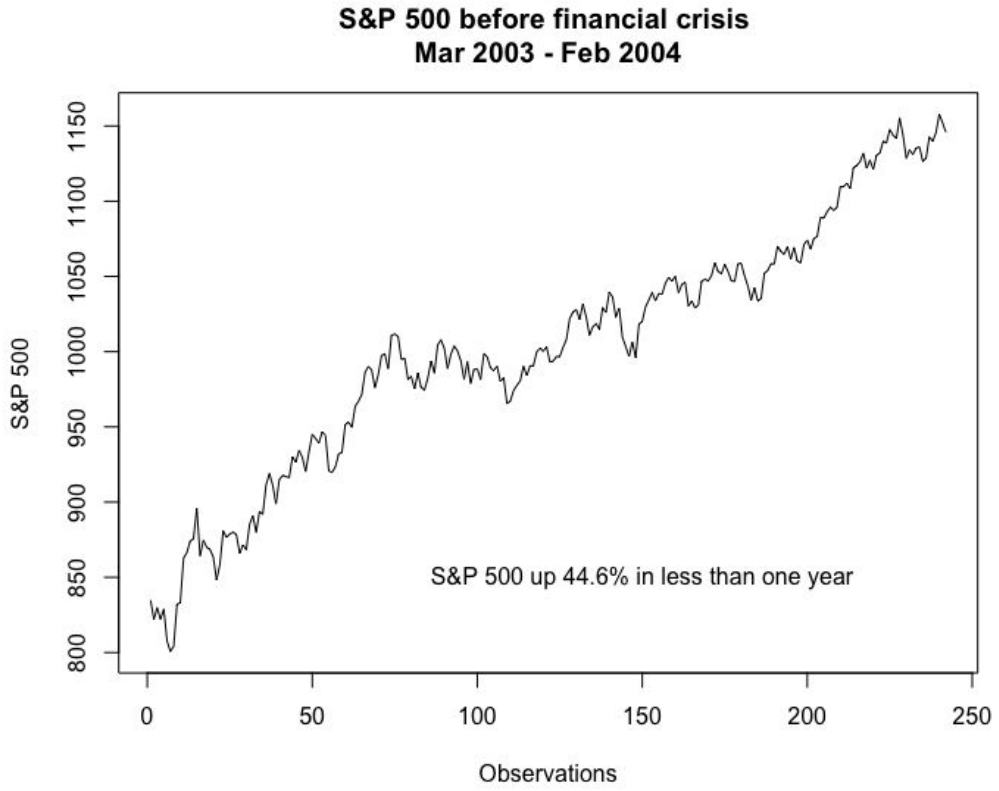
Key portfolio characteristics

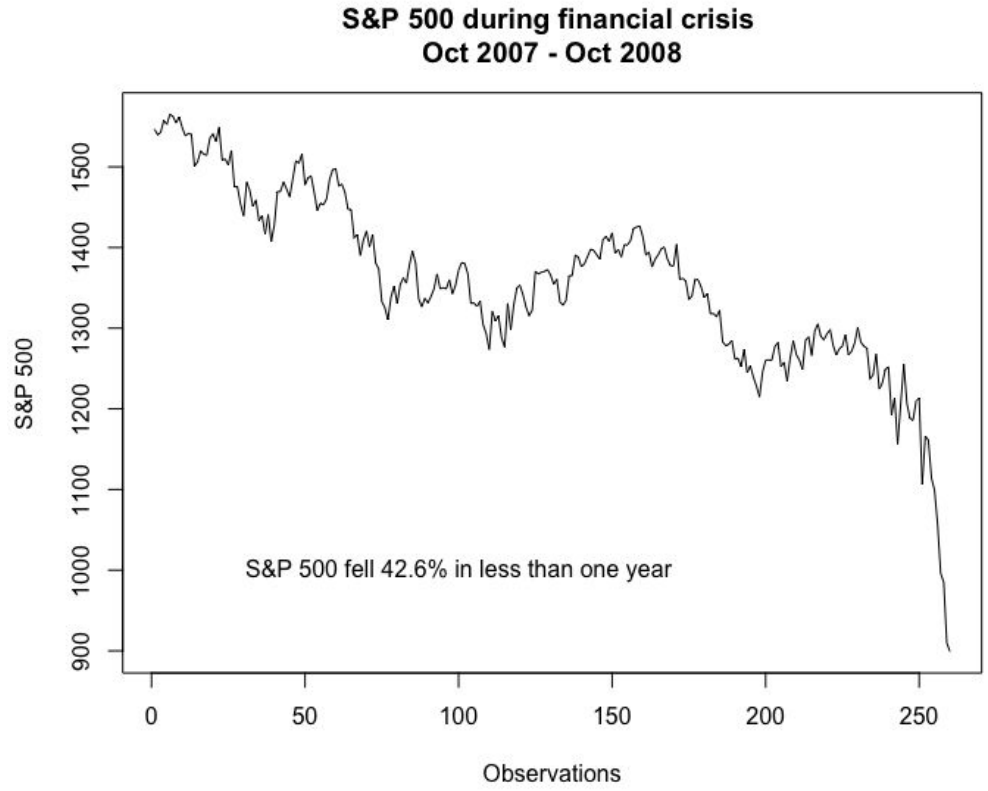
- Return
- Risk
- Complex measures of the probability distribution of portfolio returns (skewness, kurtosis, etc.)
- Similarity between in-sample and out-of-sample performance
- Robustness of assets allocation procedure
- Financial rocket scientists have a lot more to offer ☺️

Risk vs return

- The risk and return trade-off is the main principle of investing
- Future return is uncertain
- “Risk means more things can happen than will happen” (LSE)
- Extreme movements are usually not anticipated on all time scales

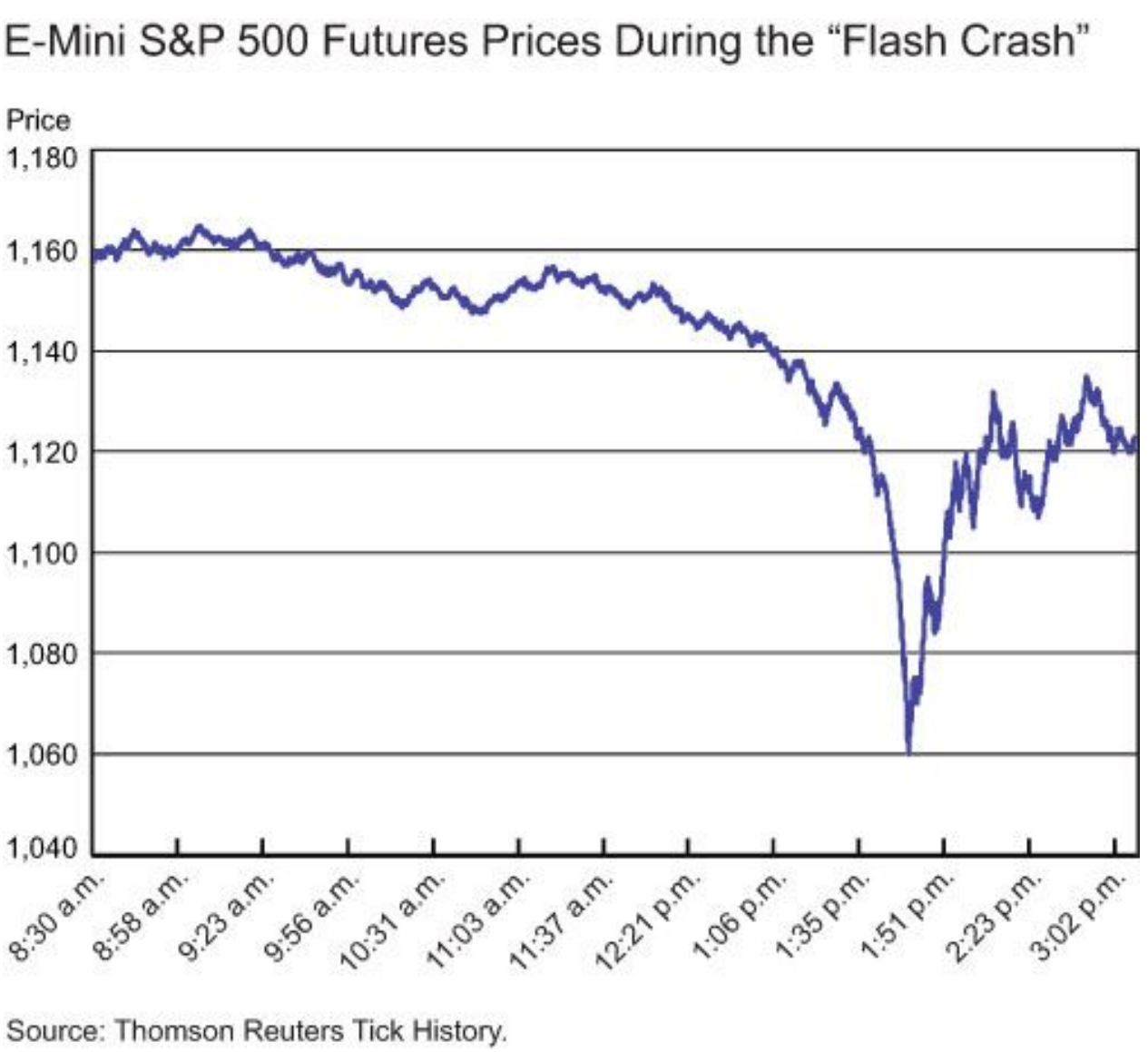
Daily data


S&P 500 before financial crisis
Mar 2003 - Feb 2004
S&P 500
800
850
900
950
1000
1050
1100
1150
0
50
100
150
200
250
Observations
S&P 500 up 44.6% in less than one year


S&P 500 during financial crisis
Oct 2007 - Oct 2008
S&P 500
900
1000
1100
1200
1300
1400
1500
0
50
100
150
200
250
Observations
S&P 500 fell 42.6% in less than one year

Flash Crash 2010 (intraday data)

- Almost 10% drop in just couple of minutes
- It’s a result of algorithmic trading
- Almost impossible to predict



Risk vs return

- The risk and return trade-off is the main principle of investing
- Future return is uncertain
- Extreme movements are usually not anticipated on all time scales
- Risk-return trade-off works because people are constantly searching for profits -> equilibrium
- Is there a free lunch in finance?

Portfolio theory: outline

- Naïve 1/n
- Markowitz theory
- Risk parity theory
- Hierarchical risk parity

Diversification

- Objective: lower our exposure to risk
- If assets are negatively correlated, you construct a low risk portfolio
- The risk of the average is **not** equal to the average of the risks
- Brent Crude and USDRUB example

Diversification

- Objective: lower our exposure to risk
- If assets are negatively correlated, you construct a low risk portfolio
- The risk of the average is **not** equal to the average of the risks
- Brent Crude and USDRUB example
- Data analysis can help you build better investment portfolios
- Understanding the decision-making process is the starting point

Decision-making process

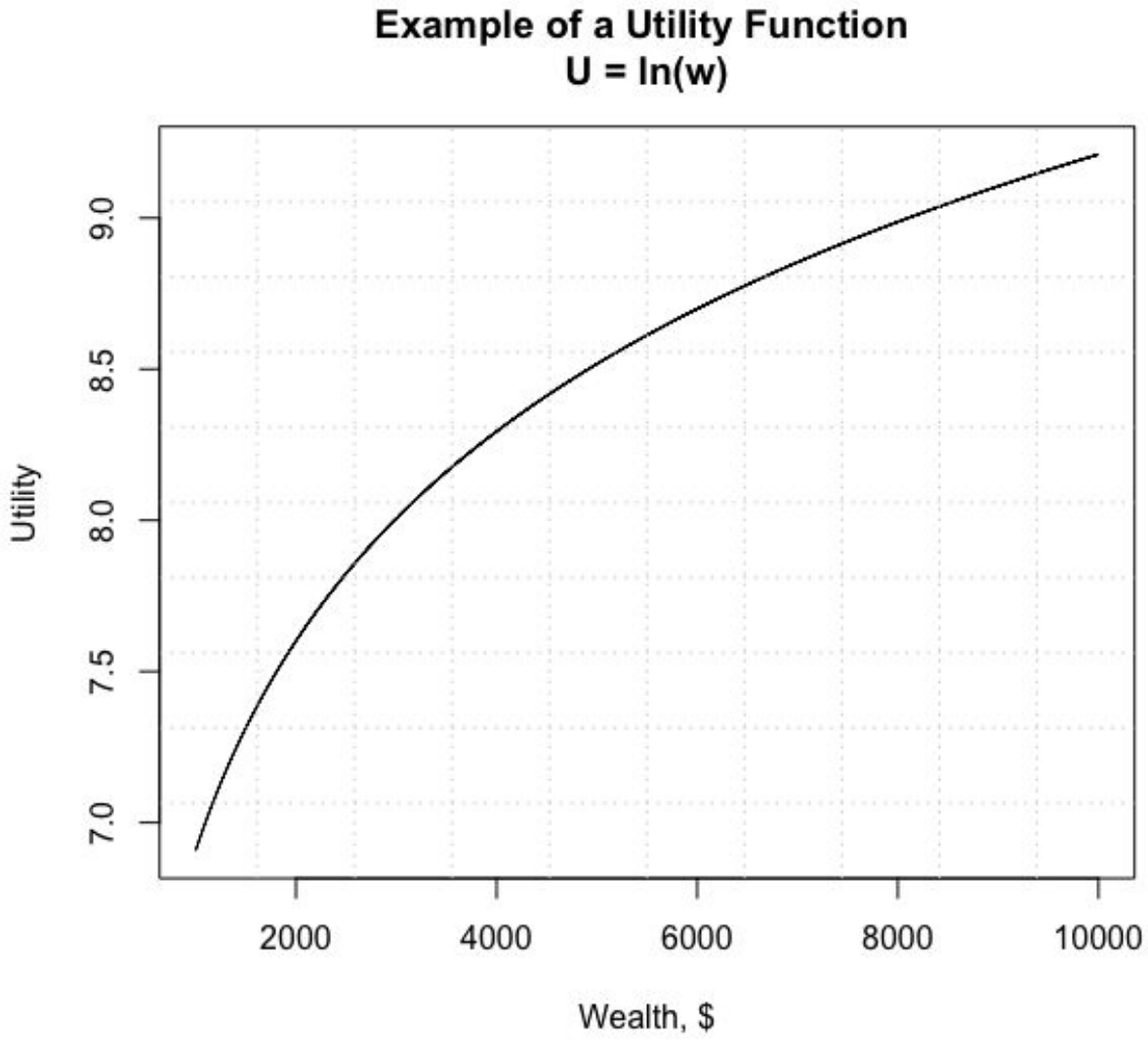
- What is rational decision-making?
- Imagine playing a game with the following rules:
  - everybody picks any number between 0 and 100
  - the goal is to guess 2/3 of the average of the numbers picked by all participants
- What is the winning strategy?

Decision-making process

- If everybody is rational, then you should pick 0!
- Financial markets are much harder to predict
- Gather information: stocks prices, what stocks move together, what is the probability of crash, etc.
- Decision-making (economics): optimization of the objective function and finding stocks that fulfill your goal
- Decision-making (neuroscience): social background, cultural biases, amount of sleep, stress, how good was your cappuccino today – everything is important☺️

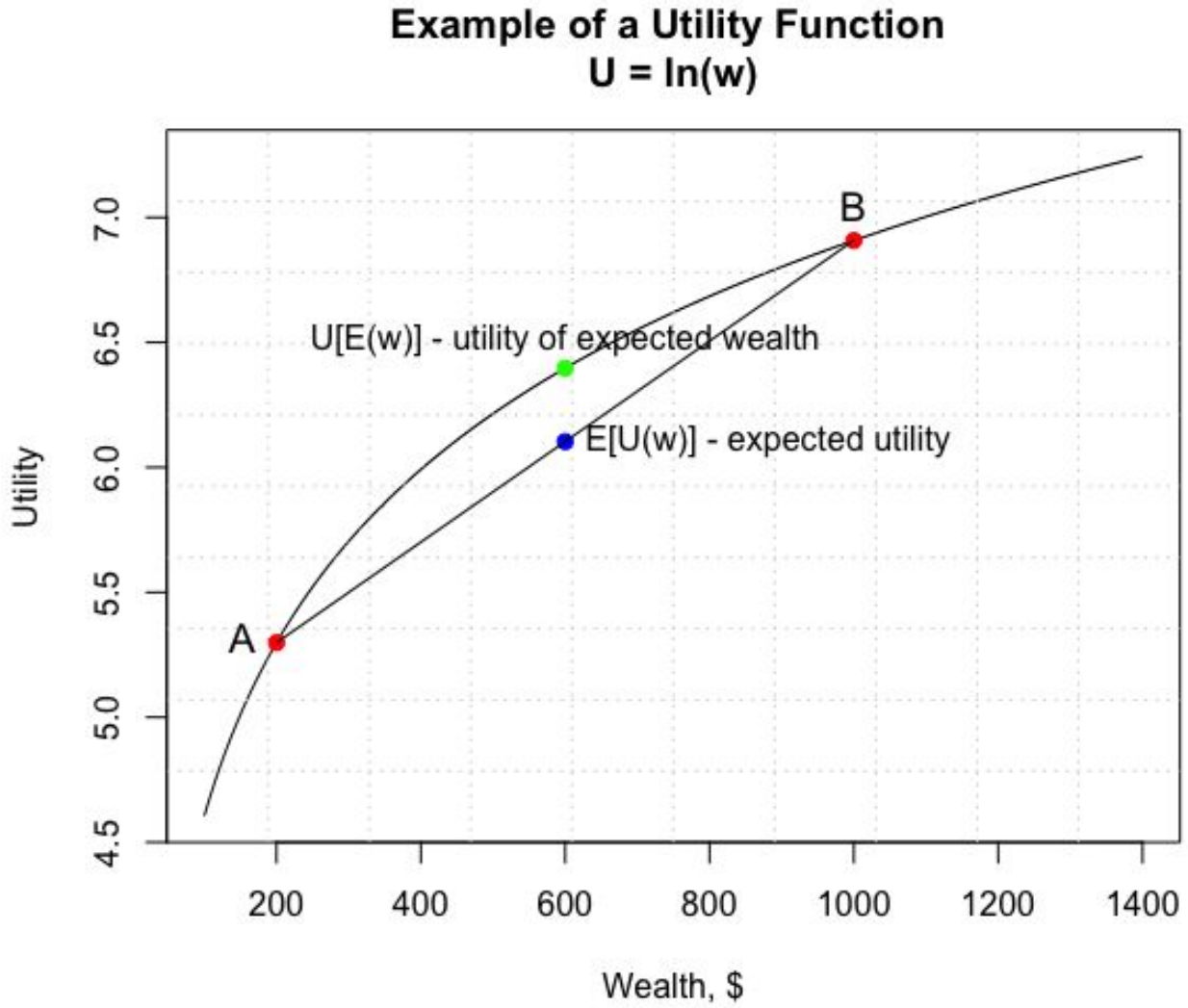
Individual preferences

- How can we formally express individual preferences?
- Utility function: $U(w)$
- Utility function reveals risk attitude



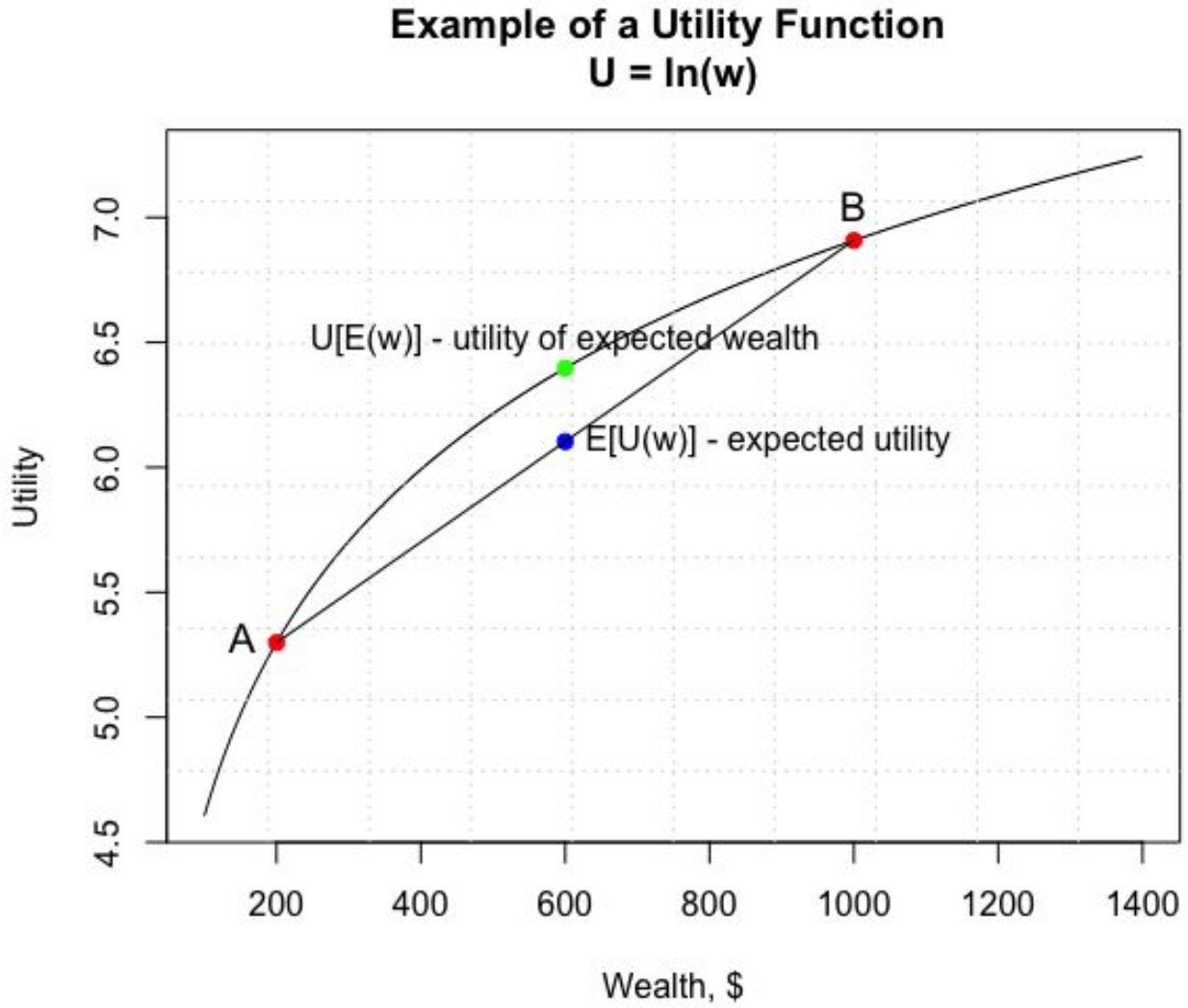
Attitude to risk

- Current wealth: $w = \$200$ (A)
- Gamble: 50% chance to win $800 (shift to B)
- Expected payoff:
$0.5 * \$0 + 0.5 * \$800 = \$400$
- Is <$400 enough to make you refrain from playing?



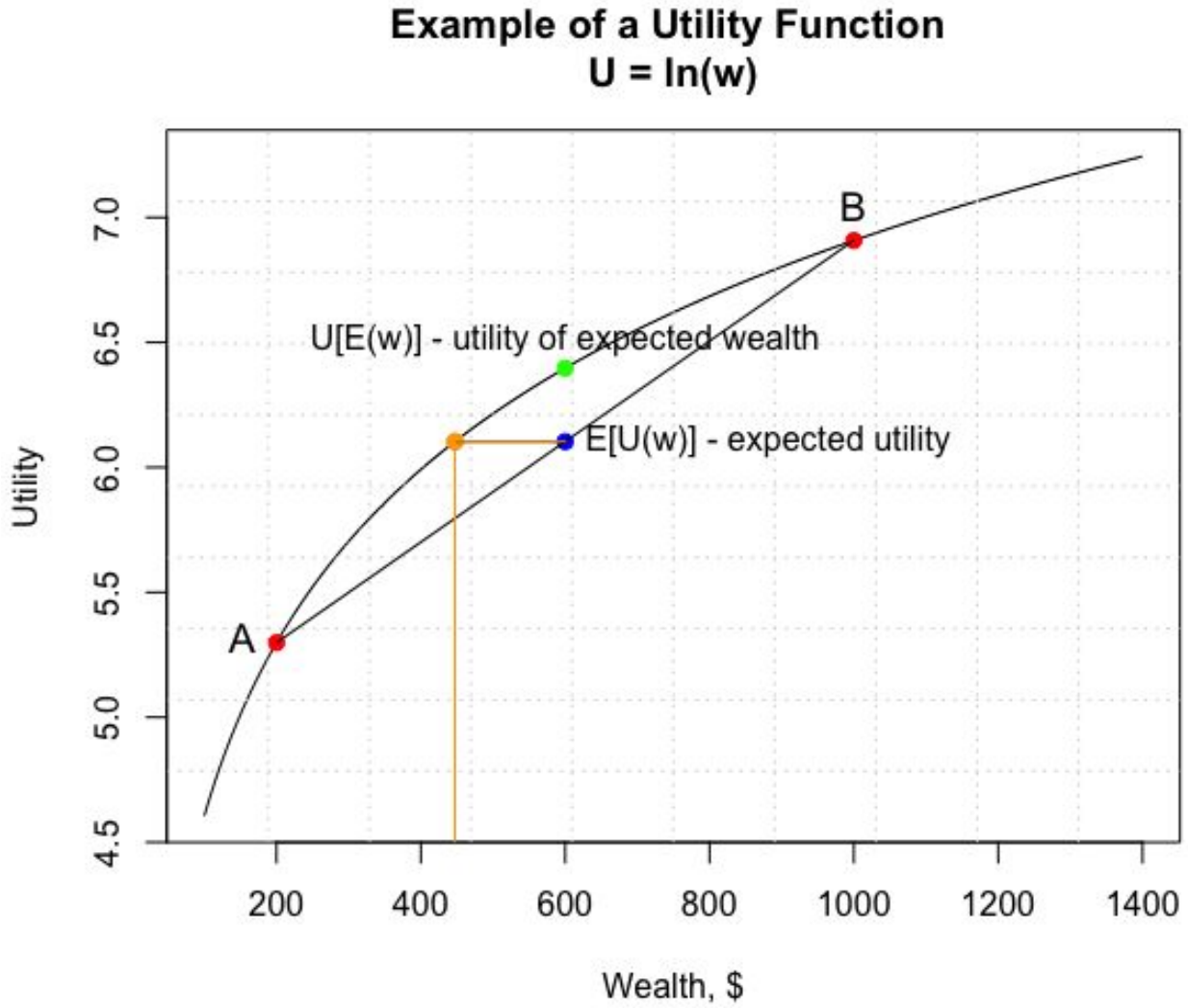
Attitude to risk

- Expected wealth:
  $E(w) = 0.5 * \$200 + 0.5 * \$1000$
  $= \$600$
- Expected utility:
  $E[U(w)]$
  $= 0.5 * ln(\$200) + 0.5 * ln(\$1000)$
  $= 6.103036$
- Utility of expected wealth:
  $U[E(w)] = \ln(\$600) \approx 6.4$
- **Risk-aversion:**
  $\boldsymbol{U[E(w)] > E[U(w)]}$



Attitude to risk

- Wealth that brings you to the expected utility level:
$$\ln(x) = 6.103036$$
$$x = e^{6.103036} \approx \$441.22$$
- Min payment to make you refrain from gambling:
$\$441.22 - \$200 = \$241.22$
- Curvature of the function defines level of your risk-aversion
- Other types of attitude to risk?



Conclusions

- Data analysis is a core element of modern financial theory
- Utility function is a way to formally describe individual preferences
- Intuitively risk seems to be an obvious concept
- Measuring risk is not trivial
- Risk-return trade-off is the key principle of investing
- Next time we'll use real data to illustrate this trade-off

Thank you!